Election of Group I; Amendments to the Claims

Responding to the Restriction Requirement contained in the action of February 14, 2006, Applicant elects Group I, including claims 1-19 and new claims 21-30 which read thereon, drawn to an ignition coil, with traverse. Applicant further amends claims 1 and 13, cancels claim 20 and adds new claims 21-30 as follows:

1. [currently amended] An inductive ignition system for an internal combustion engine operating at a voltage Vc substantially above the standard 12 volt automotive battery with one or more ignition coils Ti and associated power switches Swi, where i = 1, 2, ... n, with each coil having a primary winding of turns Np and inductance Lp, and a secondary high voltage winding for producing high voltage sparks of turns Ns and inductance Ls, the primary and secondary winding defining a turns ratio Nt equal to Ns/Np, the coils being of low inductance with one or more large air gaps within their magnetic core, [~~with primary inductance Lp below 600 uH~~] and producing spark of peak current Is above 200 ma, the system further including means for providing the higher voltage Vc and controlling the charging and spark discharging of the ignition coils from said voltage Vc in a controlled sequential manner, and further including connection means for connecting the coil Ti secondary high voltage end to a sparking means which substantially reduces EMI following spark breakdown, the system further including electronic control means for receiving signals to fire the sparking means in their proper order, the main improvement of the system being the use of one or more biasing magnets in said one or more of air gaps in the magnetic core of said low inductance coils to reduce the magnetic core area by approximately 40% for the same coil stored energy, to produce a system that as a whole is more versatile and smaller than prior such systems for the same high coil stored energy.

2. [original claim] The ignition system of claim 1 wherein a micro-controller (MCU) is used for most of the electronic controls that includes generating the charge or dwell time Tch and steering such charging or energizing of the ignition coils in the proper sequence, and firing the spark plugs associated with such coils.

3. [original claim] The ignition system of claim 2 wherein said micro-controller identifies the cylinder to be fired during engine cranking by sensing a voltage from a few turns of each coil by having all the coils fired simultaneously during cranking,

and once identified, to then have the MCU shift to sequential firing with the proper firing order to run the engine.

4. [original claim] The ignition system of claim 1 wherein the said coils have open-E type magnetic cores at the high voltage end wherein said one or more biasing magnets are located.

5. [original claim] The ignition system of claim 4 wherein the magnetic core of said coil is laminated of non-circular cross-section wherein two biasing magnet are used, one each at the core open ends.

6. [original claim] The ignition system of claim 4 wherein the magnetic core of said coil is of circular cross-section and wherein one annular ring type biasing magnet is used at the core open end.

7. [original claim] The ignition system of claim 4 wherein said core is contained in a housing with the center core leg in the housing and the outer legs outside of the housing.

8. [original claim] The ignition system of claim 4 wherein between the end of the high voltage winding of said coil and the high voltage connection of the sparking means is included a spiral winding of steel wire wound over a core of magnetic material which has a much higher resistance at and above 1 MHz relative to the DC resistance.

9. [original claim] The ignition system of claim 1 wherein said connection means are spark plug wire with spiral winding of wire of high magnetic permeability over a core including magnetic material which exhibits high loss at 1 MHz or higher frequency relative to DC.

10. [original claim] The ignition system of claim 1 wherein said sparking means are spark plugs with capacitance over 30 pF achieved by electroless chemical dip copper coating of the insulator surfaces.

11. [original claim] The ignition system of claim 10 wherein said insulator is Alumina strengthened with approximately 20% or higher zirconia.

12. [original claim] The ignition system of claim 10 wherein said spark plug has a halo-disc type firing end with recessed or concave high voltage insulator.

13. [currently amended] The ignition system of claim [~~13~~] [12] wherein said firing end has a ground ring about the center high voltage electrode wherein said ring is held by four axial supports defining four slots through which air-fuel mixture can flow.

14. [original claim] The ignition system of claim 13 wherein said axial supports define a cone with included angle θ between 30 and 90 degrees.

15. [original claim] The ignition system of claim 10 wherein said spark plug has recessed firing end insulator with large diameter center conductor of diameter approximately 0.15" along the threaded spark plug shell section to provide higher capacitance than normal along this section.

16. [original claim] The ignition system of claim 15 wherein said center conductor is high thermal conductivity material from the collection of copper, brass, and other high conductivity materials.

17. [original claim] The ignition system of claim 1 wherein said switches Swi are IGBTs and wherein their gates are turned on slowly by including high value resistance in series with the gate to substantially reduce the output voltage overshoot upon switch Swi turn-on.

18. [original claim] The ignition system of claim 1 including boost converter for raising said battery voltage Vb to a higher voltage Vc.

19. [original claim] The ignition system of claim 1 wherein said boost converter in by-directional and includes two inductor windings with biasing magnet for the magnetic core.

20. [canceled] ~~An ignition system for an internal combustion engine with more than one ignition coil Ti and associated power switches Swi, where i = 1, 2, ... n, with control means for charging and spark discharging of the ignition coils through sparking means in a controlled sequential manner, the system further including micro-controller (MCU) electronic means for receiving signals to fire the sparking means by having at least one pin Pi associated with each coil Ti , said MCU including A/D converter capability, the MCU means overall being designed to identify the cylinder that is under compression and is to be fired during that ignition firing, called the reference signal, the reference signal being found during the initial engine start up and~~

~~engine cranking by simultaneously sensing a voltage from a few secondary winding turns of at least one coil associated with each engine cylinder, wherein at least one coil per cylinder are simultaneously fired during engine cranking, providing a sense signal to its associated MCU control Pin, which the MCU compares among all the other cylinder pins Pi and finds the maximum or minimum which it identifies that as the reference firing cylinder, from which reference it can then perform proper sequential ignition firing to allow the engine to run properly, without having been provided with a cam or phase signal.~~]

21. [new] The ignition system of claim 1 wherein higher values of winding wire are possible, wherein assuming a primary turns of 60 and secondary turns of 4,200, the primary inductance Lp of 500 uH is easily achievable, and a peak spark current of 350 ma, which is above 200 ma, and a peak primary current of Ip of approximately 25 amps and a coil stored energy of approximately 155 mJ.

22. [new] The ignition system of claim 21 wherein the coil is an open-E coil with the open end at the high voltage end and wherein two biasing magnet are placed at the open ends.

23. [new] The ignition system of claim 22 wherein said biasing magnets have magnetic flux densities of 1 Tesla or higher and the magnetic flux of the coil swings between approximately -1.6 Tesla and approximately +1.6 Tesla to provide a high energy density.

24. [new] The ignition system of claim 23 wherein said switches Swi are 600 volt IGBTs and wherein their gates are turned on slowly by including high value resistance in series with the gate to substantially reduce the output voltage overshoot upon switch Swi turn-on.

25. [new] An inductive ignition system for an internal combustion engine operating at a voltage Vc with one or more ignition coils Ti and associated power switches Swi, where i = 1, 2, ... n, with each coil having a primary winding of turns Np and inductance Lp, and a secondary high voltage winding for producing high voltage sparks of turns Ns and inductance Ls, the primary and secondary winding defining a turns ratio Nt equal to Ns/Np, the coils having a open-E core wherein two large air gaps are contained within the magnetic core, and producing spark of peak current Is above 200 ma because of the large air gaps and lower inductance, and

further including connection means for connecting the coil Ti secondary high voltage end to a sparking means, the system further including electronic control means for receiving signals to fire the sparking means in their proper order,

the system comprising two biasing magnets in said two air gaps in the magnetic core to reduce the magnetic core area by approximately 40% for the same coil stored energy, to produce a system that as a whole is more versatile and smaller than systems for the same high coil stored energy without such feature.

26. [new] The ignition system of claim 25 wherein said biasing magnets have magnetic flux densities of about 1 Tesla or higher and the magnetic flux of the coil swings between approximately -1.6 Tesla and approximately +1.6 Tesla to provide a high energy density.

27. [new] The ignition system of claim 25 wherein the operating voltage Vc is between 24 and 60 volts.

28. [new] 28. The ignition system of claim 25 wherein the two biasing magnets of length lm span the space between the center core and the out core legs at the end of the core, designated as lw, where lm may be equal in length to lw, or slightly less than lw, and wherein the cross-section at right angles to the length lm is approximately equal to the total width of the laminations, and the other cross-sectional dimension, designated as the dimension h for height, is selected to accommodate the primary and secondary bobbins and to give a suitable magnetic flux density for each biasing magnet to produce a suitable average flux in each half of the core.

29. [new] The ignition system of claim 28 wherein the length of the magnetic core lc is approximately 1.6" to approximately 2.0" and the biasing magnets height h is approximately 0.2".

30. [new] An inductive ignition system for an internal combustion engine operating at a voltage Vc with one or more ignition coils Ti and associated power switches Swi, where i = 1, 2, ... n, with each coil having a primary winding of turns Np and inductance Lp, and a secondary high voltage winding for producing high voltage sparks of turns Ns and inductance Ls, the primary and secondary winding defining a turns ratio Nt equal to Ns/Np, the coils having a open-E core wherein two large air gaps are contained within the magnetic core and able to produce spark of

peak current Is above 200 ma because of the large air gaps and lower inductance, and further including connection means for connecting the coil Ti secondary high voltage end to a sparking means, the system further including electronic control means for receiving signals to fire the sparking means in their proper order,

the system comprising two biasing magnets in said two air gaps, wherein the biasing magnets span essentially the two air gaps lw and have a cross-section approximately equal to the core thickness and a height h much less than the length lc of the magnetic core, to reduce the required magnetic core area for the same coil stored energy, to produce a system that as a whole is more versatile and smaller than prior such systems for the same high coil stored energy without such features.